

PROCEEDINGS
OF
THE ROYAL SOCIETY.

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May 30, 1839.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

Professors Christopher Hansteen, Macédoine Melloni, Lambert Adolphe Jacques Quételet and Felix Savart, were severally elected Foreign Members of the Society.

Edward Davies Davenport, Esq., James Orchard Halliwell, Esq., Gilbert Wakefield Mackmurdo, Esq., and the Venerable Charles Thorp, D.D., were balloted for, and duly elected into the Society.

John Howship, Esq., was balloted for, but not elected into the Society.

The reading of a paper entitled, "Fifth letter on Voltaic Combinations; with some account of the effects of a large Constant Battery: addressed to Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain. By John Frederic Daniell, Esq., F.R.S., Professor of Chemistry in King's College, London," was resumed and concluded.

The author, pursuing the train of reasoning detailed in his preceding letters, enters into the further investigation of the variable conditions in a voltaic combination on which its efficiency depends; and the determination of the proper proportions of its elements for the economical application of its power to useful purposes. He finds that the action of the battery is by no means proportioned to the surfaces of the conducting hemispheres, but approximates to the simple ratio of their diameters; and hence concludes that the circulating force of both simple and compound voltaic circuits increases with the surface of the conducting plates surrounding the active centres. On these principles he constructed a constant battery consisting of seventy cells in a single series, which gave, between charcoal points separated to a distance of three-quarters of an inch, a flame of considerable volume, forming a continuous arch, and emitting radiant heat and light of the greatest intensity. The latter, indeed, proved highly injurious to the eyes of the spectators, in which, although they were protected by grey glasses of double thickness, a state of very active inflammation was induced. The whole of the face of the author became scorched and inflamed, as if it had been exposed for many hours to a bright midsummer's sun.

The rays, when reflected from an imperfect parabolic metallic mirror in a lantern, and collected into a focus by a glass lens, readily burned a hole in a paper at a distance of many feet from their source. The heat was quite intolerable to the hand held near the lantern. Paper steeped in nitrate of silver and afterwards dried, was speedily turned brown by this light: and when a piece of fine wire-gauze was held before it, the pattern of the latter appeared in white lines, corresponding to the parts which it protected. The phenomenon of the transfer of the charcoal from one electrode to the other, first observed by Dr. Hare, was abundantly apparent; taking place from the *zincode* (or positive pole,) to the *platinode*, (or negative pole). The arch of flame between the electrodes was attracted or repelled by the poles of a magnet, according as the one or the other pole was held above or below it: and the repulsion was at times so great as to extinguish the flame. When the flame was drawn from the pole of the magnet itself, included in the circuit, it rotated in a beautiful manner.

The heating power of this battery was so great as to fuse, with the utmost readiness, a bar of platinum, one-eighth of an inch square: and the most infusible metals, such as pure rhodium, iridium, titanium, the native alloy of iridium and osmium, and the native ore of platinum, placed in a cavity scooped out of hard carbon, freely melted in considerable quantities.

In conclusion, the author briefly describes the results of some experiments on the evolution of the mixed gases from water in a confined space, and consequently under high pressure; with a view to ascertain, first, in what manner conduction would be carried on, supposing that the tube in which the electrodes were introduced were quite filled with the electrolyte, and there were no space for the accumulation of the gases; secondly, whether, decomposition having been effected, recombination would take place at any given pressure; and lastly, whether any reaction on the current-force of the battery would arise from the additional mechanical force which it would have to overcome. These experiments he purposes pursuing at some future time.

A paper was also read, entitled, "An experimental inquiry into the influence of nitrogen in promoting vegetable decomposition, and the connexion of this process with the growth of plants." By Robert Rigg, Esq. Communicated by the Rev. J. B. Reade, A.M., F.R.S.

The author considers it as a general fact, to which there are very few if any exceptions, that vegetable bodies in the state in which they are produced in nature, undergo spontaneous decomposition when kept under circumstances favouring such an action; and that, from the decomposition of each, compound products peculiar to that substance result. A variety of experiments are detailed and tabulated; the first series of which contains those made on solutions of compounds, such as sugar, honey and extract of malt, showing that in each the amount of spontaneous decomposition is in proportion

to the quantity of nitrogen it contains. This law is found to extend to those parts of plants which are not in solution in water, but which remain in their natural state of elaboration, only having their texture broken down.

The author is led to infer from his experiments that the chemical action to which any vegetable matter is naturally disposed, may, to a certain extent, be changed into some other, differing both in its kind and in its products; and that in order to effect such a change nothing more is required than to excite in other vegetable matter mixed with the former, some action which shall preponderate over the rest, so that the whole mass may obey this new and predominant influence. The vapour which is disengaged during the rapid decomposition of vegetable matter he finds to be highly noxious; and thence draws the inference that the Author of the universe has wisely ordained, that, when young plants, containing large quantities of nitrogen, are by any means checked in their growth, they shall be consumed by certain insects; which insects may be conceived to form one of the links of that harmonious chain which binds together all the parts of the universe.

The relation between the decomposition of vegetable matter and the growth of plants is apparent from the similarity of the influence of nitrogen on both these processes: this double function which nitrogen performs in favouring chemical decomposition by the roots of plants at the same time that it assimilates the matter thus formed in their other parts, is regarded by the author as another link in the same chain. In support of this view, he adduces the different chemical constitutions of the roots of the same plants when very young, and when fully grown. He finds that when plants have to perform the important offices of providing nourishment for the rapid growth of their young and tender shoots, they contain a quantity of nitrogen two or three times greater than that which they possess when fully grown; and he concludes by showing that, in accordance with these views, the seeds, roots and plants when placed in highly decomposing or decomposed matter, cease to grow, and under these circumstances, their germinating or vegetating power being superseded by the chemical action established in the matter which surrounds them, the whole becomes one mass of contaminated and infectious matter.

June 6, 1839.

FRANCIS BAILY, Esq., Vice-President, in the Chair.

George Barker, Esq., was balloted for, and duly elected into the Society.

A paper was read, entitled, "Experiments on the chemical constitution of several bodies which undergo the vinous fermentation, and on certain results of the chemical action." By Robert Rigg, Esq., F.R.S.

The special object of this paper is to show, first, that sugar is not constituted of carbon and water only; secondly, that during the vinous fermentation water is decomposed; thirdly, that neither pure carbonic acid nor alcohol is, in the common acceptation of the term, the product of this chemical action; and fourthly, that fermented liquors owe some of their valuable qualities to peculiar products formed during fermentation.

In order to trace the various chemical changes which occur in this part of his research, the author has had recourse to numerous experiments, the details of which are recorded in tabular forms. The first table exhibits the analysis of different kinds of sugar, honey, treacle, grape-juice and extract of malt and hops, the general result of which is that all these compounds contain oxygen in excess above the proportion in which it exists in water, and that they also contain a small quantity of nitrogen. He shows, by two independent modes of experimenting, that these bodies, when in solution, cannot be the only compounds undergoing decomposition during that fermentation, which has for its product spirit and carbonic acid; and in proof of this proposition he recapitulates the different elements in the compounds at the commencement and at the conclusion of the experiments. He finds that when the proximate elements are made the subject of calculation, the weight of the alcohol (constituted of two equivalents of carbon, three of hydrogen and one of oxygen) added to that of the carbonic acid and undecomposed sugar, exceeds the weight of the sugar employed by about 7 per cent. On recapitulating the ultimate elements, he finds that the hydrogen and the oxygen in the compounds after the fermentation exceed their quantity in the sugar experimented upon, by 15 per cent. of the former, and nearly 14 per cent. of the latter; and as a proof that no material error is occasioned by the mode of experimenting, it is found that the difference between the quantity of carbon at the first and at the last is very small.

Having arrived at these conclusions, the author infers from his experiments that the water of solution is decomposed by the carbon of the dissolved vegetable matter, in every case of the vinous fermentation, and in proportions proximately represented by the following formulæ: viz.

2 equivalents of the carbon of sugar	6·12		12·24	} 14·24 olefiant gas.
2 equivalents of the hydrogen of the water 1·			2·	
1 equivalent of the carbon of the sugar...	6·12		6·12	} 22·12 carbonic acid.
2 equivalents of the oxygen of the water...	8·		16·	

This decomposition he conceives is brought about by the influence of nitrogen, a very small quantity of which enters into the constitution of the olefiant gas, forming the base of all spirituous fluids of the alcohol and ethereal kind; and thus each compound experimented upon, forms these products in proportion to the quantity of carbon which undergoes chemical change, whether that compound be sugar, soluble parts of malt, grape-juice, or any other body.

The author proceeds to inquire into the constitution of the pro-

ducts which result from this chemical action. He finds the gas which is given off to be composed of carbonic acid, mixed with a small proportion of carburetted hydrogen; and the spirit, when subjected to careful analysis, to resolve itself into carbonic acid, water, and a very small proportion of nitrogen: and in further proof of the existence of this last-mentioned element in spirit, the author has recourse to the ultimate analysis of the charcoal obtained from alcohol and olefiant gas, a mode of experimenting which he conceives is less liable to error.

He states that the views thus sought to be established are confirmed, not merely by these direct experiments, but likewise by other changes which fermented liquors undergo on being kept under circumstances favourable for further chemical action; and that having proved the existence of such a compound as one constituted of carbon, hydrogen and nitrogen, and shown that water is decomposed during its formation, he thinks we are enabled to account for many other changes which occur during the decomposition of vegetable matter and the growth of plants: whence he proceeds to show that evidence of the presence of such a compound as the above in fermented liquors is afforded by the changes which take place in consequence of keeping them.

On subjecting to ultimate analysis the semi-fluids obtained by exposing fermented liquors to a temperature of 110° Fahr., the author found a decided difference between the chemical constitution of those procured from old, and those from new vinous fluids; and on searching for the law by which these differences are regulated, he found that the spirituous part entered into such combination with the excess of oxygen before referred to, and the undecomposed vegetable matter, so as to form with them new compounds.

After experiencing some difficulty in effecting a separation of these newly formed bodies, he found that while rectified pyroxylic spirit, of the specific gravity from 830 to 835, scarcely dissolved an appreciable quantity of the extract of malt and hops, considerable portions of the semi-fluids obtained from old ale and old porter were, by agitating, dissolved therein. By using this spirit as a solvent he effected such a separation as enabled him to discover decided differences between the proximate chemical constitution of the semi-fluids obtained from old ale and old porter, and those from liquors of the same description when new.

In accounting for many of the phenomena which accompany the vinous fermentation, the author observes that the small excess of oxygen found in all these compounds, which undergo this chemical action, is an essential and indispensable circumstance; a conclusion which is corroborated both by the formation of these new compounds which have been described, and by the generation of the acetic, tartaric, or malic acid, which is found in fermented liquors at all times, and in quantities varying according to the situations under which these fluids have been kept.

June 13, 1839:

JOHN W. LUBBOCK, Esq., V.P. and Treas., in the Chair.

The ballot for Edwin Guest, Esq., was postponed in consequence of the number of Fellows required by the Charter not being present.

The following papers were read, viz.:—

“Researches on the Tides. Tenth Series. On the Laws of Low Water at the Port of Plymouth, and on the permanency of mean water.” By the Rev. W. Whewell, B.D., F.R.S., Fellow of Trinity College, Cambridge.

In this memoir the author investigates the question, how far the *mean water*, that is the height of the tide midway between high and low water, is permanent during the changes which high and low water undergo. That it is so approximately at Plymouth having been already ascertained by short series of observations, it was desirable to determine the real amount of this permanency by induction from longer series of observations. A period of six years was chosen for that purpose; and the method of discussing these observations was the same, with slight modifications, as in former researches.

The height of low water, cleared from the effects of lunar parallax, and very nearly so from those of lunar declination, and compared with the height of high water, similarly cleared, enabled the author to ascertain whether the mean water also was affected by the semi-menstrual inequality. The results of the calculation show that the height of mean water is, within two or three inches, constant from year to year: and that, for each fortnight, it has a semi-menstrual inequality amounting to six or seven inches;—the height being greatest when the transit is at 6h. and least when at 11 h.,—the immediate cause of this inequality being, that the semi-menstrual inequality of low water is greater than that of high water: this inequality, however, is probably modified by local circumstances.

These researches have also verified the theoretical deduction, that the height both of low and of high water being affected by the moon's declination, their mean height partakes of the variations in this latter element, in successive years, consequent on the change of position of the moon's orbit. At Plymouth the increase in mean low water amounts to about two inches for each degree of increase in the declination. In the high water this change is less marked.

The parallax correction of the height of low water is obtained from all years alike, by taking the residue of each observation, which remains when the semi-menstrual inequality is taken away, and arranging these residues, for each hour of transit, according to the parallax. The declination correction is obtained in a manner analogous to the parallax correction, from each year's observations, with some correction for the variation in the mean declination of the moon in each year.

“Researches on the Tides. Eleventh Series. On certain Tide

Observations made in the Indian Seas." By the Rev. W. Whewell, B.D., F.R.S., Fellow of Trinity College, Cambridge.

This paper contains the results of the examination by the author of certain series of tide observations made at several places in the Indian Seas, which were forwarded to the Admiralty by the Hon. East India Company. These localities were Cochin, Corringa River, Surat roads in the Gulf of Cambay, Gogah, on the opposite side of the same gulf, and Bassadore, in the Island of Kissmis in the Persian Gulf.

"On the Electrolysis of Secondary Compounds." In a letter addressed to Michael Faraday, Esq., D.C.L., F.R.S., Fullerian Professor of Chemistry in the Royal Institution of Great Britain, &c., &c. By John Frederic Daniell, Esq., F.R.S., Professor of Chemistry in King's College, London.

The discovery of definite electrochemical action naturally suggests the inquiry into the relative proportion of that part of a voltaic current, which, in the case of its decomposing a saline solution, is carried by the elements of the water, and that part which is carried by the elements of the saline compound, and into the definite relations, if any such there be, subsisting between the two electrolytes so decomposed. This question was the origin of the investigation which forms the subject of the present letter. The power which the author employed in this experimental inquiry was that of a small constant battery of thirty cells, six inches in height, with tubes of earthenware, charged in the manner he has described in his former communications to the Society. The result of the first experiment evidently indicated that the decomposition of one equivalent of water was accompanied by the decomposition of an exact equivalent of sulphate of soda. The author then endeavours to ascertain whether the power of the current is equally divided between what had hitherto been regarded as the two equivalent electrolytes. The first experiments he made in order to determine this point seemed to lead to the extraordinary conclusion, that the same current which is just sufficient to separate an equivalent of oxygen from an equivalent of hydrogen in one vessel, will at the same time separate an equivalent of oxygen from one of hydrogen, and also an equivalent of sulphuric acid from one of soda in another vessel.

The author then examines the remarkable phenomena relative to the transfer of matter from one electrode to the other without the decomposition of the transported compound; a phenomenon which was first observed by Mr. Porret in glass cells divided into two compartments by a diaphragm of bladder.

Having observed that the products of electrolyzation cannot be kept long separate in their respective cells, on account of the ultimate mixture of the liquids on the platinode side of the diaphragm, the author was led to construct an apparatus by which this evil is remedied much more perfectly, and to which he gives the name of *the double diaphragm cell*. It consists of two cells, formed of two glass cylinders, with collars at their lower ends, fitted by grinding

to a stout glass tube bent into the form of the letter U, and firmly fixed on a wooden post. The current transmitted by this double cell is more retarded than when passing through the single cell, on account of the greater distance of the electrodes; but it answers its intended purpose of stopping the transfer of the liquid even in the case of saline solutions, and there is still sufficient conducting power to render it powerfully effective. Experiments were then made to ascertain whether in the electrolysis of the dilute sulphuric acid any transfer of the acid takes place; from which the author concludes that during the electrolysis of an equivalent of water, a portion of acid passes over from the platinode to the zincode; and possibly an equal portion of water also passes over from the zincode to the platinode. These experiments appear to confirm the results previously obtained; namely, that one fourth of an equivalent of sulphuric acid passes from the platinode to the zincode for every single equivalent of a compound which has been electrolyzed by the current.

The author then proceeds to examine the following question, viz.: does the acid during its transfer, in the case of the mixed acid and water, or do the acid and the alkali, in the case of the saline solution, convey any portion of the current which effects the simultaneous decomposition of the water in both instances? He next investigates the action of the voltaic current on the aqueous solution of the chlorides, as the simpler constitution of this class of salts promised to throw some light on the nature of the electrolysis of secondary compounds.

The results of all these experiments tend to the establishment of the fundamental principle, that the force which is measured by its definite action at any one point of a circuit cannot perform more than an equivalent proportion of work at any other point of the same circuit; and that the current, which is measured by its electrolysis of an equivalent of simple chloride of lead, cannot at the same time be sufficient to electrolyze an equivalent of chloride of sodium, and an equivalent of water, at the same electrodes. The sum of the forces which held together any number of *ions*, in a compound electrolyte, could, moreover, only have been equal to the force which held together the elements of a simple electrolyte, electrolyzed at the same moment in one circuit.

In applying these principles to the electrolysis of the solution of sulphate of soda, water seems to be electrolyzed, and at the same time the acid and alkali of the salt appear in equivalent proportions with the oxygen and hydrogen, at their respective electrodes. It cannot be admitted, that after the decomposition of the water there is any excess of force applicable to the decomposition of the salt; but it must be concluded that the only electrolyte which yields is the sulphate of soda, the *ions* of which, however, are not the acid and alkali of the salt, but an *anion*, composed of an equivalent of sulphur, and four equivalents of oxygen and the metallic *cathion*, sodium. From the former, sulphuric acid is formed, at the *anode*, by secondary action, and the evolution of one equivalent of oxygen; and from the latter, soda at the cathode, by the secondary action of

the metal, and the evolution of an equivalent of hydrogen. The formation of these secondary electrolytes, and compound anions and cathions, will probably furnish the key to the explanation of many of those decompositions and recompositions, to which the presence of water is necessary, such as those of nitric acid on the metals, and the formation of Schoenbein's circuit: but the author reserves for a future opportunity the examination of this hypothesis, as well as of the general question.

"Experimental Researches on the mode of operation of Poisons."
By James Blake, Esq. Communicated by P. M. Roget, M.D., Sec. R.S.

In this paper the author examines more particularly the action of those poisons which appear to produce death by affecting the nervous system.

After reviewing the evidence adduced in support of the opinion, that the effects of some poisons are owing to an impression made on the nerves of the part to which they are directly applied, he proceeds to relate a series of experiments undertaken in order to show with what rapidity the blood is circulated through the body, and tending to prove, that a substance may be generally diffused through the system in nine seconds after its introduction into the veins.

Experiments are then related in which the more rapidly fatal poisons had been used, and in which it was found, that an interval of more than nine seconds always elapsed, between the administration of a poison, and the appearance of the first symptoms of its action. The mere contact of a poison with a large surface of the body appears to be insufficient to give rise to general effects, as long as it is prevented from entering into the general circulation.

Various causes of fallacy in experiments of a similar kind, which have been adduced in support of an opposite opinion, are pointed out. The following is a summary of the conclusions arrived at by the author.

1. The time required for a substance to penetrate the capillary vessels, may be considered as inappreciable.
2. The interval elapsing between the absorption of a substance by the capillaries, and its general diffusion through the body, may not exceed nine seconds.
3. An interval of more than nine seconds always elapses between the introduction of a poison, into the capillaries, or veins, and the appearance of its first effects.
4. If a poison be introduced into a part of the vascular system nearer the nervous centres, its effects are produced more rapidly.
5. The contact of a poison with a large surface of the body is not sufficient to give rise to general symptoms, as long as its diffusion through the body is prevented.

June 20, 1839.

JOHN W. LUBBOCK, Esq., V.P. and Treas., in the Chair.

Sir Thomas Dyke Acland, Bart., M.P., Edwin Guest, Esq., and John Hogg, Esq., M.A., were balloted for and severally elected into the Society.

The following papers were read: viz.

1. "Inquiries concerning the Elementary Laws of Electricity." Third Series. By W. Snow Harris, Esq., F.R.S.

The author states, that it has been his object, in this series of investigations, to perfect the methods of electrical measurement, whether relating to the quantity of electricity, intensity, inductive power, or any other element requiring an exact numerical value, and by operating with large statical forces both attractive and repulsive, to avoid many sources of error inseparable from the employment of extremely small quantities of electricity, such as those affecting the delicate balance used by Coulomb. He then describes some improvements in his hydrostatic electrometer, an instrument already mentioned in his first paper, which, although not available for the measurement of such minute forces as those to which the balance of torsion is applicable, is still peculiarly delicate and well adapted to researches in statical electricity. Its indications depending on the force between two opposed planes operating on each other under given conditions, are reducible to simple laws, and are hence invariable and certain; the attractive force between the discs is not subject to any oblique action, is referable to any given distance, and may be estimated in terms of a known standard of weight. The author next proceeds to the further consideration of the subject of his former papers, viz. the elementary laws of electrical action. He proves, by the following experiments, that induction invariably precedes, or at least accompanies attraction and repulsion.

A circular disc of gilded wood, about six inches in diameter, is suspended by an insulating thread of varnished silk from a delicate balance; a delicate electroscope is attached to this disc, and the whole is counterpoised by a weight. A similar disc insulated on a glass rod, and having also an electroscope attached to it, is placed at any convenient distance immediately under the former. One of the lower discs being charged with either electricity and the other remaining insulated and neutral, the electroscope of the neutral disc begins to rise, whilst that of the charged disc, already in a state of divergence, tends to collapse: when these respective effects ensue, the suspended disc descends the charged disc. Two inductive actions are indicated in this experiment, the one the author considers to be a direct induction, the other a reflected induction.

If the two discs are both charged with opposite electricities, on opposing them as before, the electroscopes begin to fall back, at

which moment the discs appear to attract each other. But if the discs are both charged with the same kind of electricity, the divergence of the electroscopes increases, and at this instant the suspended disc recedes from that which is fixed, being apparently repelled by it.

The author proceeds to examine strictly the nature of this inductive influence, and adduces experiments to render probable that it is in some way dependent on the presence of an exquisitely subtle form of matter which may become disturbed in bodies, and assumes new states or conditions of distribution.

Very numerous experiments are detailed, showing the influence of changes of different intensity, of changes in the dimensions and distances of the opposed discs, of interposed bodies of different forms, &c. on the phenomena of induction. The author concludes by giving the following formulæ as the results of his investigations regarding the elementary laws of electrical induction and attraction. In these expressions Q = quantity of charge, T = the direct induction, q = the quantity of electricity displaced, t = its intensity, T' = the reflected induction, q' = the disturbed quantity, t' = its intensity, q'' = the total quantity in the opposed charged surface, A = the surface, D = the distance between the opposed points, F = the force of attraction.

For the direct induction :

$$T = \frac{Q}{\sqrt{D}} \qquad t = \frac{Q^2}{D}$$

For the reflected induction :

$$T' = q' = \frac{Q}{D} \qquad t' = \frac{Q^2}{D^2} \qquad q'' = \frac{Q}{\sqrt{D}}$$

For the attractive force between a charged and a neutral free conductor :

$$F = \frac{Q^2}{D^2} \qquad F = \frac{T}{A^2}$$

For the force between two unchangeable surfaces, one positive the other negative :

$$F = \frac{Q^2}{D}$$

2. "On the Conditions of Equilibrium of an Incompressible Fluid, the particles of which are acted upon by Accelerating Forces." By James Ivory, Esq., K.H., M.A., F.R.S., &c.

The intention of this paper is to examine the principles and methods that have been proposed for solving the problem of which it treats, with the view of obviating what is obscure and exceptionable in the investigation usually given of it.

The principle first advanced by Huyghens is clearly demonstrated, and is attended with no difficulty. This principle requires that the resultant of the forces in action at the surface of a fluid in equi-

brium and at liberty, shall be perpendicular to that surface : and it is grounded on this, that the forces must have no tendency to move a particle in any direction upon the surface, that is, in a plane touching the surface.

In the *Principia*, Sir Isaac Newton assumes that the earth, supposed a homogeneous mass of fluid in equilibrium, has the figure of an oblate elliptical spheroid of revolution which turns upon the less axis : and, in order to deduce the oblateness of the spheroid from the relation between the attractive force of the particles, and their centrifugal force caused by the rotatory velocity, he lays down this principle of equilibrium, that the weights or efforts of all the small columns extending from the centre to the surface, balance one another round the centre. The exactness of this principle is evident in the case of the elliptical spheroid, from the symmetry of its figure : and it is not difficult to infer that the same principle is equally true in every mass of fluid at liberty and in equilibrium by the action of accelerating forces on its particles. In every such mass of fluid, the pressure, which is zero at the surface, increases in descending below the surface on all sides : from which it follows that there must be a point in the interior at which the pressure is a maximum. Now this point of maximum pressure, or centre, is impelled equally in all directions by all the small columns standing upon it and reaching to the surface ; and as the pressure in every one of these columns increases continually from the surface to the centre, it follows that the central point sustains the total effect of all the forces which urge the whole body of fluid. It follows also, from the property of a maximum, that the central point may be moved a little from its place without any variation of the pressure upon it : which proves that the forces at that point are zero. Thus the point of maximum pressure is in stable equilibrium relatively to the action of the whole mass of fluid : which establishes Newton's principle of the equilibrium of the central columns in every instance of a fluid in equilibrium and at liberty.

The two principles of Huyghens and Newton being established on sure grounds, the next inquiry is, whether they are alone sufficient for determining the figure of equilibrium. Of this point there is no direct and satisfactory investigation : and, in applying the two principles to particular cases, it has been found that an equilibrium determined by one, is not in all cases verified by the other ; and even in some instances, that there is no equilibrium when both principles concur in assigning the same figure to the fluid. Further researches are therefore necessary to dispel the obscurity still inherent in this subject.

In a mass of fluid in equilibrium, if we suppose that small canals are extended from a particle to the surface of the mass, the particle will be impelled with equal intensity by all the canals ; for, otherwise, it would not remain immoveable, as an equilibrium requires. It has been inferred that the equal pressures of the surrounding fluid upon a particle are sufficient to reduce it to a state of rest. Hence has arisen the principle of equality of pressure, which is generally

admitted in this theory. Now, if the matter be considered accurately, it will be found that the only point within a mass of fluid in equilibrium which is at rest by the sole action of the surrounding fluid, is the central point of Newton, or the point of maximum-pressure. The reason is that, on account of the maximum, the pressure of all the canals terminating in the central point, increases continually as the depth increases; so that, besides the pressures of the canals, there is no other cause tending to move the particle. With respect to any other particle, the pressure caused by the action of the forces in some of the canals standing upon the particle, will necessarily increase at first in descending below the surface, and afterwards decrease; so that the effective pressure transmitted to the particle, is produced by the action of the forces upon a part only of the fluid contained in such canals. If a level surface be drawn through any particle, it is proved in the paper, that the equal pressures of the surrounding fluid on the particle, are caused solely by the forces which urge the portion of the fluid on the outside of the level surface, the fluid within the surface contributing nothing to the same effect. Thus a particle in a level surface is immoveable by the direct and transmitted action of the fluid on the outside of the level surface; but it will still be liable to be moved from its place unless the body of fluid within the level surface have no tendency to change its form or position by all the forces that act on its own particles.

What has been said not only demonstrates the insufficiency of the principle of equality of pressure for determining the figure of equilibrium of a fluid at liberty, but it points out the conditions which are necessary and sufficient for solving the problem in all cases. The pressure must be a maximum at a central point within the mass: it must be zero at the surface of the fluid: and, these two conditions being fulfilled, there will necessarily exist a series of interior level surfaces, the pressure being the same at all the points of every surface, and varying gradually from the maximum quantity to zero. Now all the particles in the same level surface have no tendency to move upon that surface, because the pressure is the same in all directions: wherefore if we add the condition that every level surface shall have a determinate figure when one of its points is given, it is evident, both that the figure of the mass will be ascertained, and that the immobility of the particles will be established.

Maclaurin's demonstration of the equilibrium of the elliptical spheroid will always be admired, and must be instructive from the accuracy and elegance of the investigation. That geometer was the first who discovered the law of the forces in action at every point of the spheroid; and it only remained to deduce from the known forces the properties on which the equilibrium depends. These properties he states as three in number; and of these, the two which relate to the action of the forces at the surface and the centre of the spheroid, are the same with the principles of Huyghens and Newton, and coincide with two of the conditions laid down above. The third property of equilibrium, according to Maclaurin, consists in this, that every particle is impelled equally by all the rectilineal canals stand-

ing upon it and extending to the surface of the spheroid. Now it does not follow from this property that a particle is reduced to a state of rest within the spheroid, by the equal pressures upon it of the surrounding fluid: because these pressures may not be the effect of all the forces that urge the mass of the spheroid, but may be caused by the action of a part only of the mass. Maclaurin demonstrates that the pressure impelling a particle in any direction is equivalent to the effort of the fluid in a canal, the length of which is the difference of the polar semi-axes of the surface of the spheroid and a similar and concentric surface drawn through the particle, which evidently implies both that the pressures upon the particle are caused by the action of the fluid between the two surfaces, and likewise that the pressures are invariably the same upon all the particles in any interior surface, similar and concentric to the surface of the spheroid. Such surfaces are therefore the level surfaces of the spheroid; and every particle of the fluid is at rest, not because it is pressed equally in all directions, but because it is placed on a determinate curve surface, and has no tendency to move on that surface on account of the equal pressures of all the particles in contact with it on the same surface. Maclaurin seems ultimately to have taken the same view of the matter, when he says that* "the surfaces similar and concentric to the surface of the spheroid, are the level surfaces at all depths." It thus appears that the conditions laid down above as necessary and sufficient for an equilibrium, agree exactly with the demonstration of Maclaurin, when the true import of what is proved by that geometer is correctly understood.

The general conditions for the equilibrium of a fluid at liberty being explained, the attention is next directed to another property, which is important, as it furnishes an equation that must be verified by every level surface. If we take any two points in a fluid at rest, and open a communication between them by a narrow canal, it is obvious that, whatever be the figure of the canal, the effort of the fluid contained in it will be invariably the same, and equal to the difference of the pressures at the two orifices. As the pressure in a fluid in equilibrium by the action of accelerating forces, varies from one point to another, it can be represented mathematically only by a function of three co-ordinates that determine the position of a point: but this function must be such as is consistent with the property that obtains in every fluid at rest. If a, b, c , and a', b', c' , denote the co-ordinates of the two orifices of a canal; and $\phi(a, b, c)$ and $\phi(a', b', c')$ represent the pressures at the same points; the function $\phi(a, b, c)$ must have such a form as will be changed into $\phi(a', b', c')$, through whatever variations the figure of a canal requires that a, b, c must pass to be finally equal to a', b', c' . From this it is easy to prove that the co-ordinates in the expression of the pressure must be unrelated and independent quantities. The forces in action are deducible from the pressure; for the forces produce the variations of the pressure. As the function that stands for the press-

ure is restricted, so the expressions of the forces must be functions that fulfil the conditions of integrability, without which limitation an equilibrium of the fluid is impossible. Thus, when the forces are given, the pressure may be found by an integration, which is always possible when an equilibrium is possible: and as the pressure is constant at all the points of the same level surface, an equation is hence obtained that must be verified by every level surface, the upper surface of the mass being included. But although one equation applicable to all the level surfaces may be found in every case in which an equilibrium is possible, yet that equation alone is not sufficient to give a determinate form to these surfaces, except in one very simple supposition respecting the forces in action. When the forces that urge the particles of the fluid, are derived from independent sources, the figure of the level surfaces requires for its determination as many independent equations as there are different forces.

In the latter part of the paper the principles that have been laid down are illustrated by some problems. In the first problem, which is the simplest case that can be proposed, the forces are supposed to be such functions as are independent of the figure of the fluid, and are completely ascertained when three co-ordinates of a point are given. On these suppositions all the level surfaces are determined, and the problem is solved, by the equation which expresses the equality of pressure at all the points of the same level surface.

As a particular example of the first problem, the figure of equilibrium of a homogeneous fluid is determined on the supposition that it revolves about an axis and that its particles attract one another proportionally to their distance. This example is deserving of attention on its own account; but it is chiefly remarkable, because it would seem at first, from the mutual attraction of the particles, that peculiar artifices of investigation were required to solve it. But in the proposed law of attraction, the mutual action of the particles upon one another is reducible to an attractive force tending to the centre of gravity of the mass of fluid, and proportional to the distance from that centre: which brings the forces under the conditions of the first problem.

The second problem investigates the equilibrium of a homogeneous planet in a fluid state, the mass revolving about an axis, and the particles attracting in the inverse proportion of the square of the distance. The equations for the figure of equilibrium are two; one deduced from the equal pressure at all the points of the same level surface; and the other expressing that the stratum of matter between a level surface and the upper surface of the mass, attracts every particle in the level surface in a direction perpendicular to that surface. No point can be proved in a more satisfactory manner than that the second equation is contained in the hypothesis of the problem, and that it is an indispensable condition of the equilibrium. Yet, in all the analytical investigations of this problem, the second equation is neglected, or disappears in the processes used for simplifying the calculation and making it more manageable: which is a remarkable

instance of attempting to solve a problem, one of the necessary conditions being omitted.

The equations found in the second problem, are solved in the third problem, proving that the figure of equilibrium is an ellipsoid.

3. "Report of a Geometrical Measurement of the Height of the Aurora Borealis above the Earth." By the Rev. James Farquharson, LL.D., F.R.S.

The principal object to which the author directed the inquiries of which he here gives an account, is the determination by geometrical measurement of the height of the aurora borealis, and of the altitude and azimuth of the point to which the streamers seem to converge, and which has been termed the *centre of the corona*: these latter determinations constituting important data for enabling us to form a clear conception of the whole definite arrangement and progress of the meteor, and also a correct judgement of the degree of reliance to be placed on the methods employed for measuring its height above the earth. The paper is chiefly occupied with the details of the observations made or collected by the author, with their critical discussion, with the correction of some misapprehensions which have existed respecting the views stated by the author in his former papers, and with a reply to the strictures of M. Arago on those views.

The result of the geometrical measurement of one particular aurora, gave as the height of its upper edge, 5693 feet above the level of the Manse at Alford; and the vertex of its arch was found to be 14,831 feet northward of the same place. The vertical extension of the fringe of streamers was 3212 feet; leaving 2481 feet for the height of the lower edge above the level of Alford. The tops of the Corean hills, immediately under the aurora, are about 1000 feet higher than that level; so that the lower edge of the arch was only 1500 feet above the summit of that range of hills.

4. "On the Phosphates." By John Dalton, D.C.L., F.R.S., &c.

The author takes a review of the labours of preceding chemists which bear upon the subject of the atomic constitution of phosphoric acid, and the salts in which it enters as a constituent; and shows their conformity with the views he has already advanced on the subject. A supplement is added, giving an account of the effects of various degrees of heat on the salt denominated the *pyrophosphate of soda*.

5. "On the Arseniates." By the Same.

The author here examines the conformity of the results of the analysis of the salts of arsenic with his theory, in the same manner as he has done with the phosphates in the preceding paper.

6. "On the Constitution of the Resins." Parts II. and III. By J. F. W. Johnston, Esq., F.R.S.

In this paper the author, pursuing the train of investigation of

which he has already given an account in a former communication, gives tabulated results of his chemical examination of several varieties of gamboge, and formulæ expressing their chemical constitution. A detailed account is given of the properties of the gambodiac acid, and of the salts it forms with various bases, such as the gambodiates of potash and soda, of ammonia, and of different earths and metals, particularly lime, strontia, magnesia, lead, copper, zinc, and silver. He concludes from this investigation that the most probable formula for gamboge is $C_{40}H_{23}O_8$. In the analysis, however, of every specimen, there occurred a deficiency of carbon, amounting to nearly one per cent.; a deficiency supposed to be due to a change produced during the preparation of the natural resin for the market. By a heat of 400° Fahr. gamboge undergoes a partial decomposition; a resin, soluble in alcohol, and another resin, insoluble in that menstruum being formed: the formula representing the latter being $C_{40}H_{23}O_9$. Gamboge forms with the metallic oxides numerous salts, the existence and constitution of which, however, the experiments of the author only render probable.

The inquiries of the author were next directed to the chemical constitution of the resin of guaiacum, and to the properties of the salts it forms with various bases. He then examines the *acaroid resin*, which exudes from the *Xanthorrhæa hastilis*, and is often known by the name of *Botany-bay resin*, or *yellow gum*; and finds its formula to be $C_{40}H_{20}O_{12}$, showing that it contains more oxygen than any other resinous substance hitherto analyzed.

The general conclusions drawn by the author from these researches are the following.

1. Many of the resins may be represented by formulæ exhibiting their elementary constitution, and the weight of their equivalents, in which 40 C is a constant quantity.
2. There appear to be groups, in which the equivalents, both of carbon and the hydrogen, are constant, the oxygen only varying; and others, in which the hydrogen alone varies, the two other elements being constant.

In the third part of the same series of investigations, the author examines the constitution of the resin of Sandarach of commerce, which he finds to consist of three different kinds of resin, all of which possess acid properties. In like manner he finds that the resin of the *Pinus abies*, or spruce fir, commonly called *Thus*, or ordinary *Frankincense*, consists of two acid resins; the one easily soluble in alcohol, the other sparingly soluble in that menstruum. The gum resin *olibanum*, of commerce, was found to consist of a mixture of at least two gum-resins, the resinous ingredient of each of which differs from that of the other in composition and properties.

7. "On the Markings of the Eel-back Dun variety of the Horse, common in Scotland;" in a letter to P. M. Roget, M.D., Sec. R.S. By W. Macdonald, M.D., Fellow of the Royal College of Physicians of Edinburgh, F.R.S. Ed., F.L.S., &c. Communicated by Dr. Roget.

The author states some observations which he has made on the coloured marks apparent in a variety of the horse, common in Scotland, and there called the *Eel-back Dun*, and which afford grounds for doubting the accuracy of the conclusions deduced in a paper, by the late Earl of Morton, published in the Philosophical Transactions for 1820. The title of the paper referred to is "A Communication of a singular fact in Natural History," namely, that a young chestnut mare of seven-eighths Arabian blood, after producing a female hybrid by a male quagga, had subsequently produced, by a fine black Arabian horse, a filly and a colt, both of which had the character of the Arabian breed as decidedly as could be expected where fifteen-sixteenths of the blood are Arabian, but in colour, in the hair of their manes, and the markings of the back and legs, bore a striking resemblance to the quagga.

The author, finding that similar markings are very commonly met with on the Eel-back dun ponies of Scotland, suggests, that as the breed of the mare in question was not pure she may have inherited the tendency to those peculiar markings. He moreover observes, that the cross bar markings on the legs are not found in the *quagga*, but only in the *zebra*, which is a species quite distinct from the quagga; a fact which he considers as completely overturning the reasoning by which the conclusions stated in Lord Morton's paper were deduced. The facts, he thinks, admit of a more natural explanation, and one more consistent with the known physiological laws of development, by supposing the stain in the purity of the mare's Arab blood to have arisen from the circumstance of an early progenitor of the mare having belonged to the Eel-backed dun variety, the peculiarities of which reappeared in a later generation.

8. "On the Structure and Functions of the Spleen." By Thomas Gordon Hake, M.D. Communicated by Francis Kiernan, Esq., F.R.S.

The author, passing in review the various opinions which have been advanced by anatomists respecting the intimate structure of the spleen, arrives at the conclusion that hitherto only vague and premature inductions have been made. It is generally admitted that the fibrous envelope of this organ is formed of the external fibres of the splenic vein; and that from the internal surface of this envelope fibrous prolongations are continued into the interior of its substance, giving support to a fine cellular membrane, which is continuous with their edges, and variously reflected so as to constitute cells. The parenchyma, or solid structure of the spleen, everywhere accompanies these membranous productions, and forms the exterior walls of the cells; being composed of branches of the splenic arteries, of the granular terminations of those arteries constituting the *splenic grains* of Malpighi, of *venules*, which ramify around the splenic grains, and of *cellules*, into which the venules open, and from which the splenic veins take their rise. The author concludes, as the result of his inquiries, that a dilatable cellular tissue exists, containing venous blood, between the granules within which the arteries ter-

minate, and the venules on the outer side of the splenic grains: that the venous membrane, which is continued from the cells to the cellules, as well as to the venules, becoming more and more attenuated, but without changing its essential structure, gradually loses its tubular form, and resumes its primitive character of cellular tissue; and that the artery, in like manner, is limited in its distribution within the granules by a cellular structure, which becomes vicarious of it, and determines the function it has to perform.

The author, in conclusion, offers some observations on the probable functions of the spleen. He considers the opinion which supposes that organ to be distended, at particular times, with arterial blood, as being completely refuted by the evidence derived from the preceding account of its minute structure; and suggests the probability of the spleen being rather a diverticulum for venous blood.

The paper is accompanied by seven highly finished drawings illustrating the structures described.

9. "Additional Experiments on the formation of Alkaline and Earthy Bodies by chemical action when carbonic acid is present." By Robert Rigg, Esq., F.R.S.

The author gives a detailed account of several experiments in which sugar, water, and yeast only were employed, and from which he deduces the conclusion that alkaline and earthy matters are formed by chemical action. In one set of experiments, some of which were made in silver, others in china, and others in glass apparatus, after the vinous fermentation had gone on during five days, the quantity of ashes obtained was, in the silver apparatus eighteen, in the china nineteen, and in the glass fifteen times greater than the previous quantity. A further examination of these ashes showed that they consisted of potass, soda, lime, and a residue not acted upon by muriatic acid. The author states that, however irreconcilable to our present chemical knowledge this important conclusion may at first sight appear, yet when it is taken in connexion with the decomposition of other vegetable matter, and with the phenomena which accompany the growth of plants, it may not excite surprise; and may be regarded as in harmony with the phenomena of natural science. He concludes by offering suggestions towards extending the inquiry into the subject of the formation of bones of animals by the action of the powers inherent in their organization.

10. "On the Difference of Colour in different parts of the Bodies of Animals." By James Alderson, M.A., M.D., late Fellow of Pembroke College, Cambridge. Communicated by P. M. Roget, M.D., Sec. R.S., &c.

The hypothesis advanced by the author in explanation of the well-known partial absence of the coloured pigment or *rete mucosum*, in different parts of the human body, and that of other animals, is that it is due to the union or adhesion of the epidermis and the true skin, so as to exclude the *rete mucosum*. He supports this hypothesis by the analogy of a cicatrix, which is the result of an organization of a

certain portion of lymph, poured out from the cut surfaces of a wound, as part of the process of nutrition, or as the consequence of a small amount of inflammation, induced either from mechanical irritation, or other accidental circumstance. This hypothesis was suggested by the colourless appearance of the cicatrix from the section of the umbilical cord in the negro, and also of that seen by the author at the umbilicus of the bottle-nosed whale, the *Hyperoodon bidentatus*.

The Society then adjourned over the long vacation to meet again on the 21st November next.